Cloud Type and Ice Microphysics Products with Combined Radar and Lidar Measurements

Zhien Wang

University of Wyoming

Other Contributors:

Min Deng, University of Wyoming

Jay Mace, University of Utah

Hajime Okamoto, University of Kyushu

Kenneth Sassen, University of Alaska

Thanks for the supports of CALIPSO team !

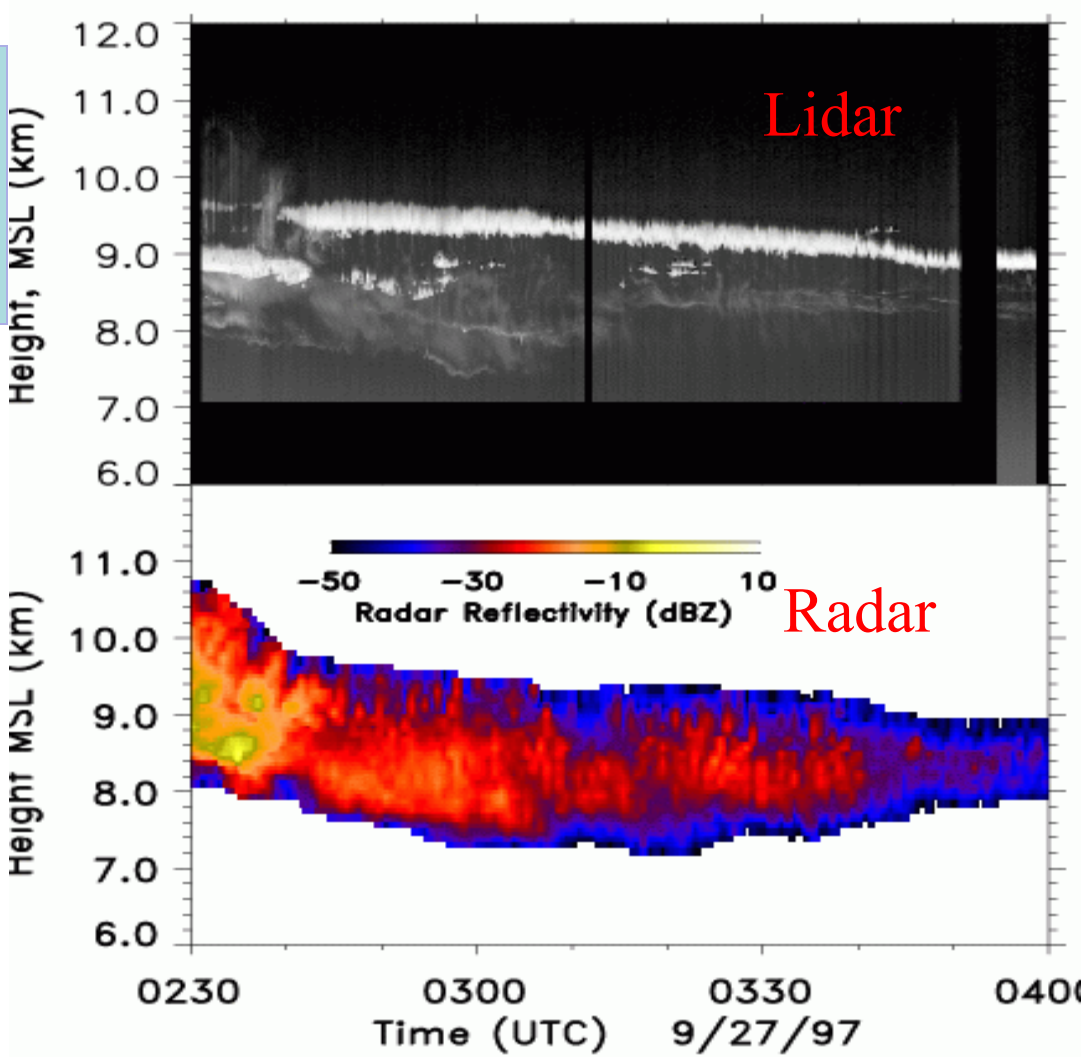
Why Combining Radar and Lidar for Cloud Study

Different wavelengths:
Lidar: 0.5 um
CPR: 3300 um

1. ***Different scattering intensities from the same particles***

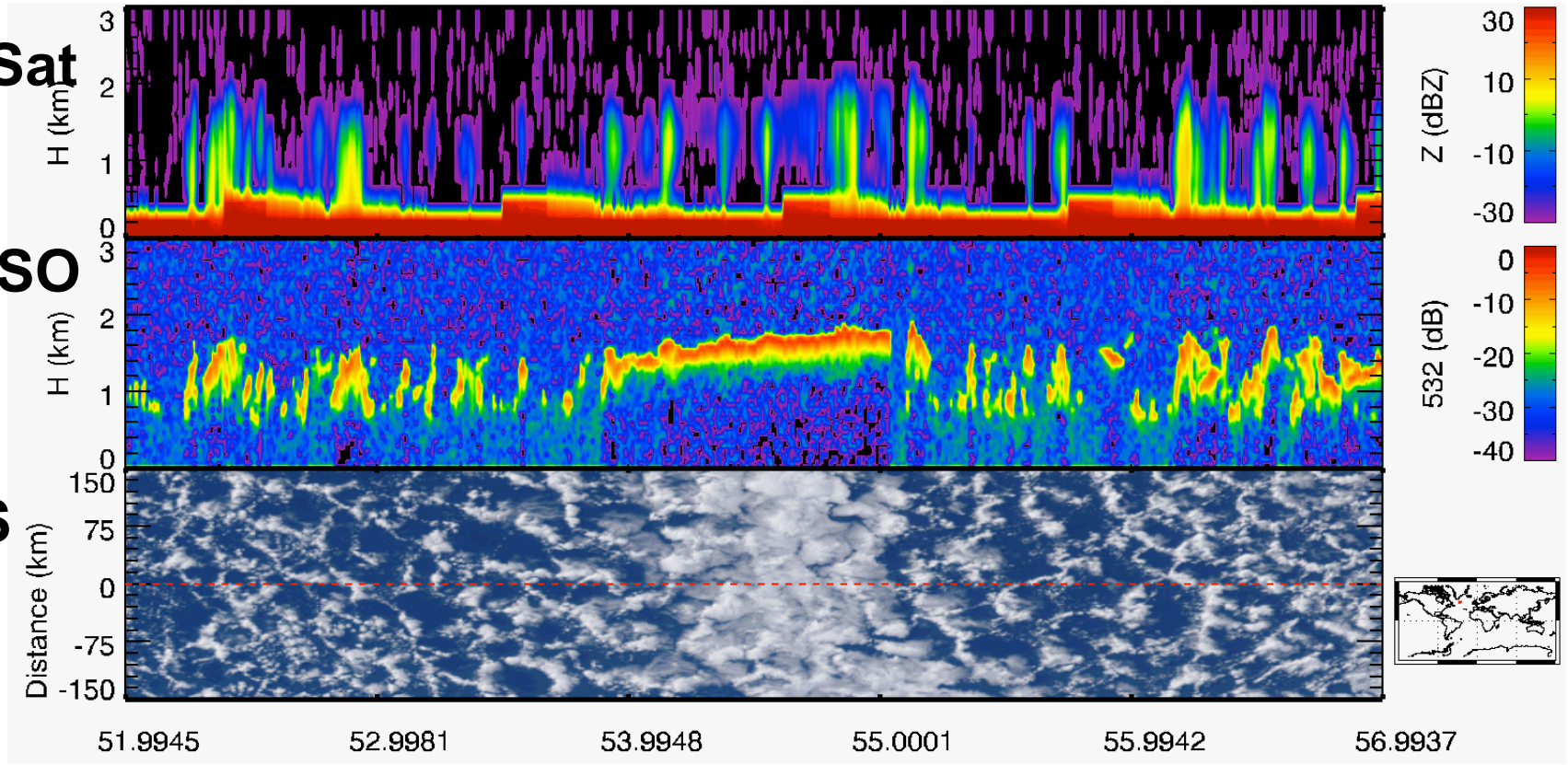
2. ***Different sensitivities for different size particles***

3. ***Different attenuations***



An example of ground-based lidar and radar measurements.

An example of collocated CloudSat and CALIPSO measurements



Combined radar-lidar measurements provide improved cloud physical and optical properties !

- CloudSat products with combined radar-lidar measurements
  - **2B-GEOPROF-lidar**: cloud vertical distribution.
  - **2B-CLDCLASS-lidar**: Cloud phase and type.
  - **2C-ICE**: ice cloud microphysical properties.
  - **2B-FLXHR-lidar**: heating rate profile with lidar aerosol and cloud properties.

Cloud type classification -motivations

1. The need of algorithm implementation .

2. Different impacts on Earth energy and water cycles.

Global annual mean overcast sky cloud-induced radiative flux changes in W m^{-2}

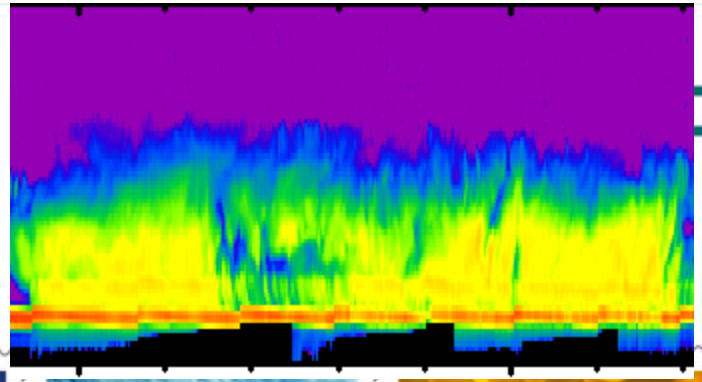
	Ci	Cs	Deep convective	Ac	As	Ns	Cu	Sc	St
TOA total:	5.4	-27.7	–65.5	-16.3	-58.8	-78.2	–29.8	-67.0	-76.8

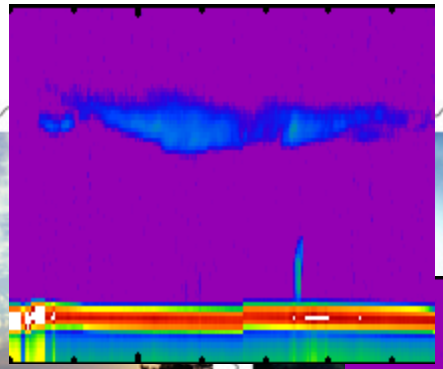
From Chen et al. *J. Climate*, **13**, 264-286, 2000

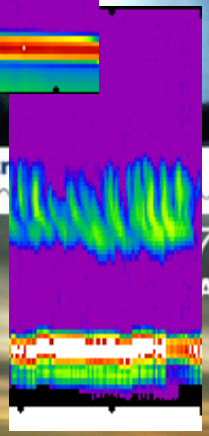
3. **Different types of clouds are usually associated with different cloud dynamics.**

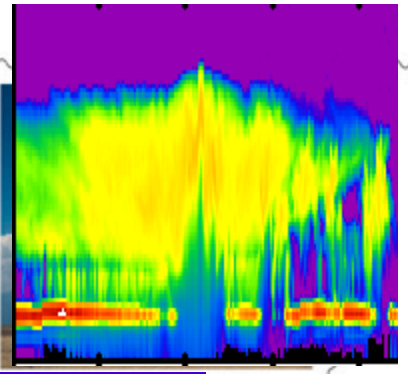
4. **Climate changes can result in changing frequency of cloud types and changing properties of a cloud type. The combination of them determines the change of the role of clouds in the Earth water and energy cycles.**

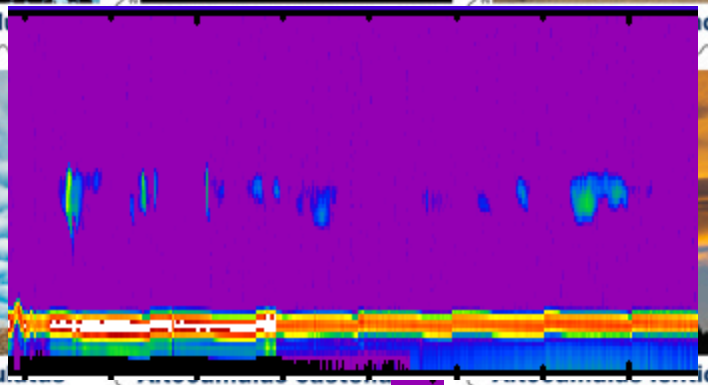
C L O U P E S

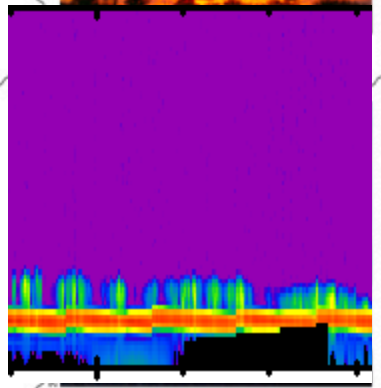












Cirrus radiatus

Cirrostr

Cirrocumulus und

cus

Altostratus translucidus

Altocumulus undu

icularis

Stratocumulus undulatus

Stratus opacus

Cumulus humilis

Cumulus congestus

Cumulonimbus with tornado

.37 x 15 $5.55

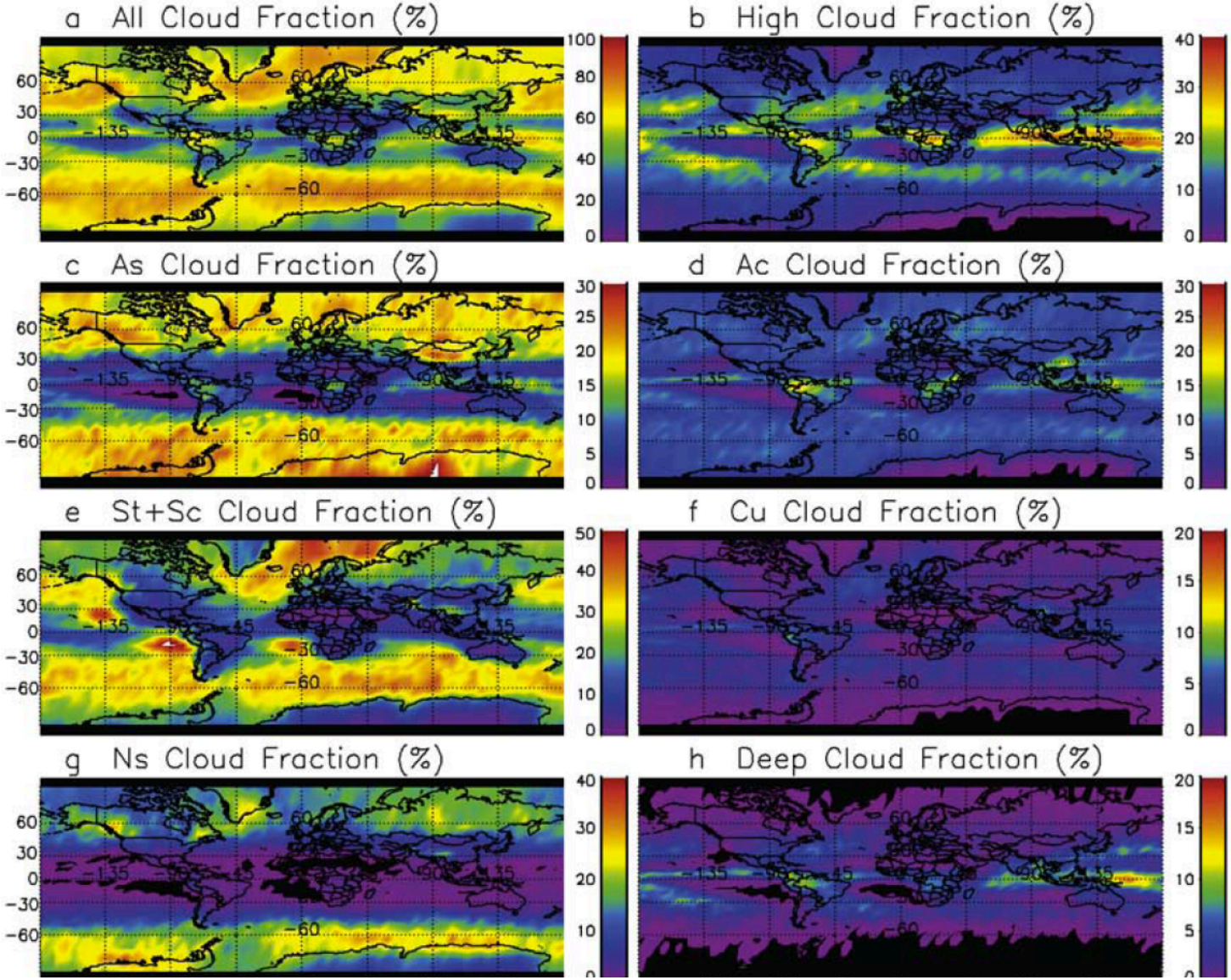
X1111

PLATE POSITION

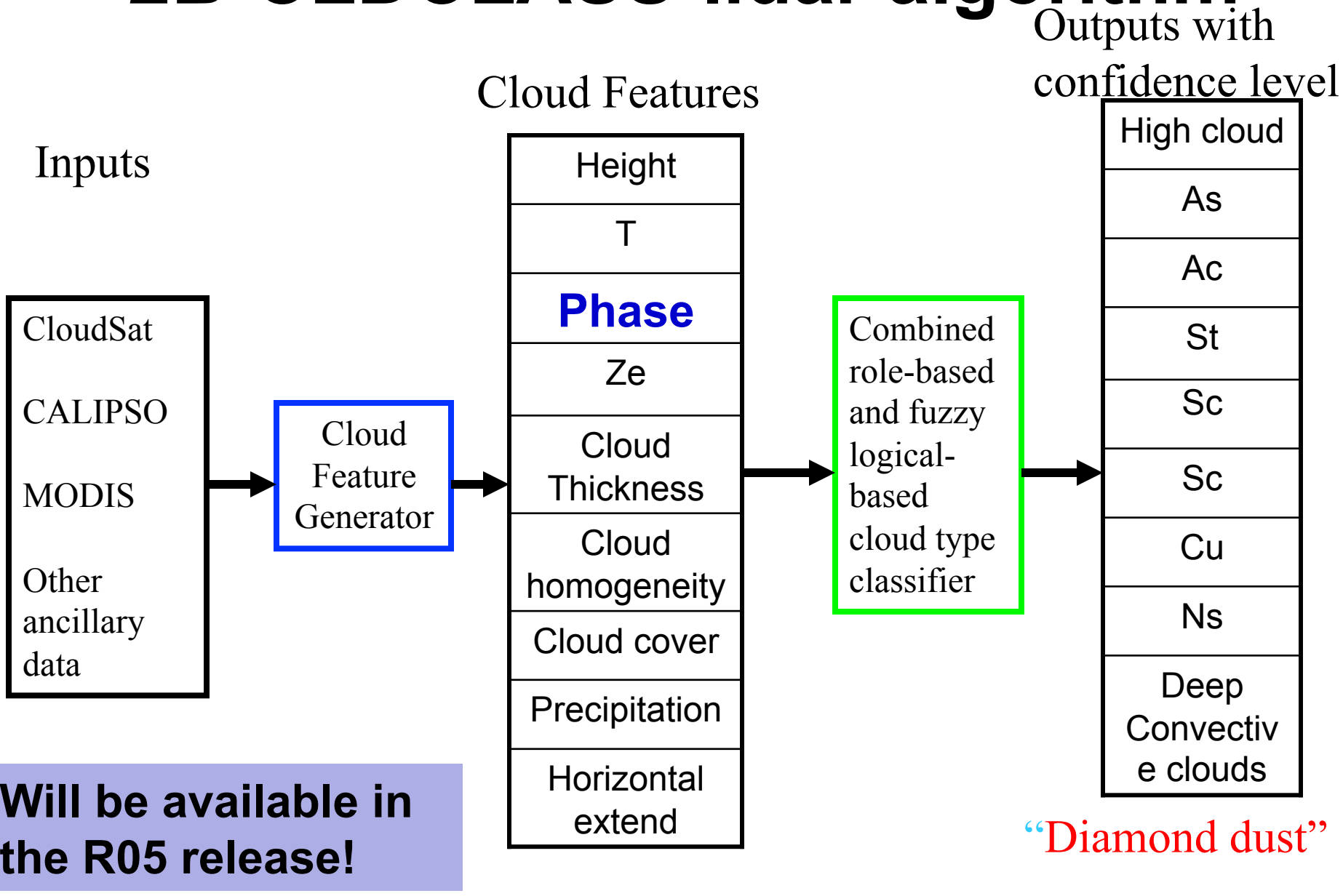
X1111

Cloud Type Distribution

2B-CLDCLASS (radar-only)

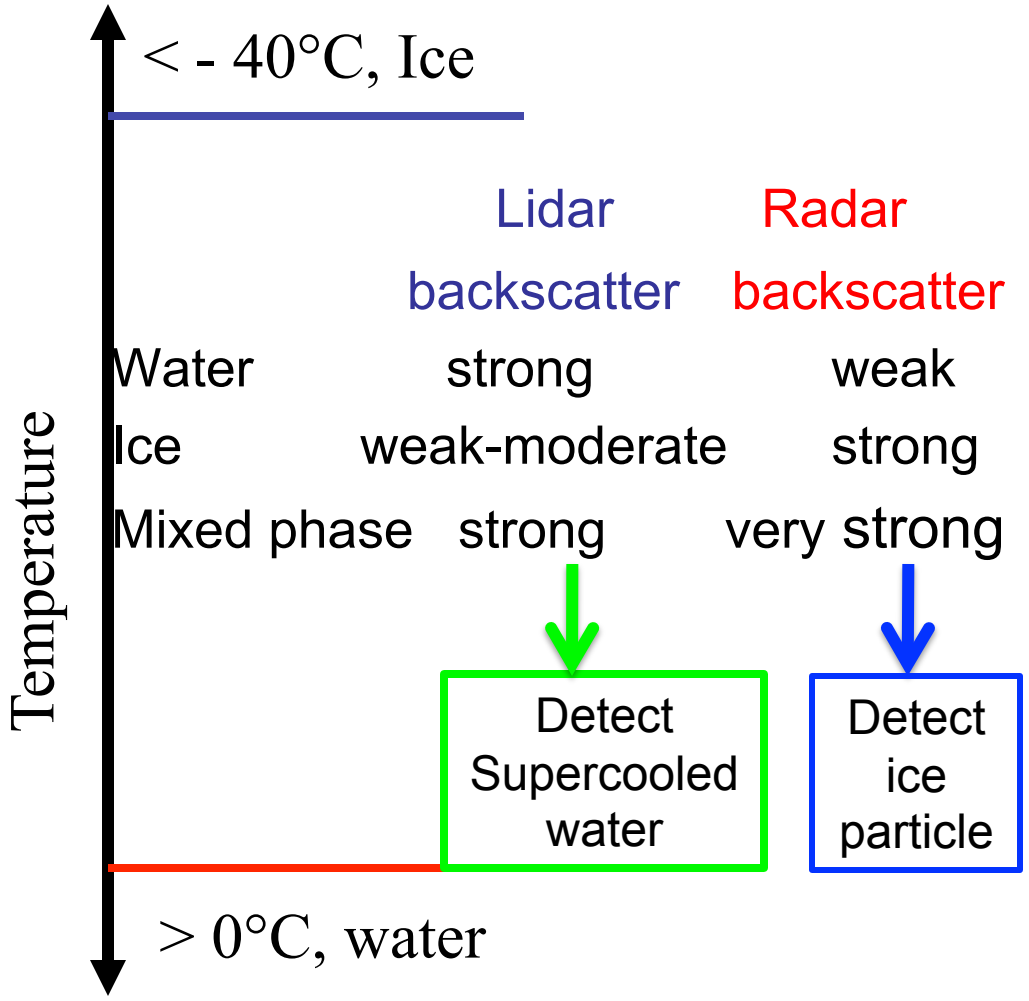


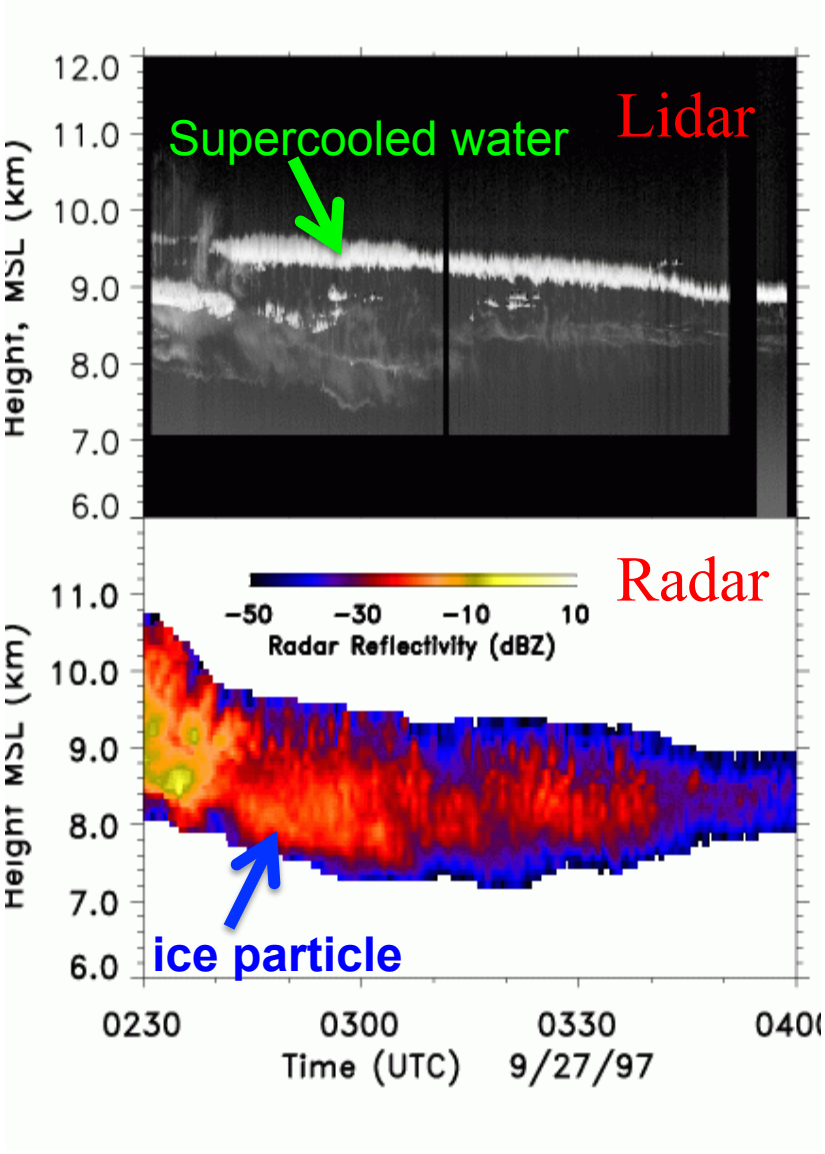
The general structure of 2B-CLDCLASS-lidar algorithm



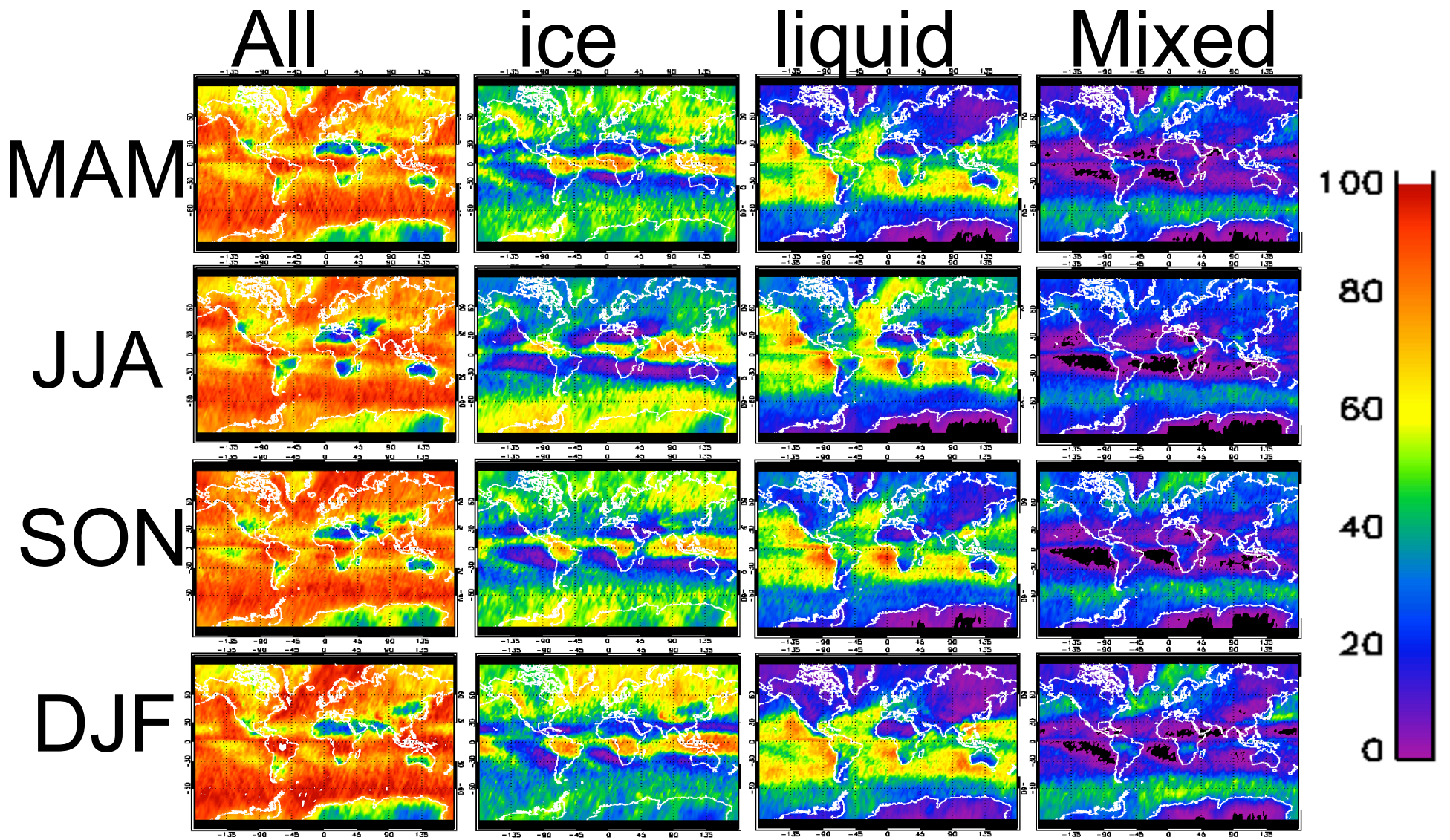
Will be available in the R05 release!

Combined lidar-radar Cloud Phase Identification





Global cloud phase distribution



2C-ICE Product –*ice cloud microphysical property*

Min Deng, University of Wyoming
Jay Mace, University of Utah
Zhien Wang, University of Wyoming
Hajime Okamoto, University of Kyushu

2C-ICE CloudSat Operational Product Retrieval Algorithm

Developed based on the optimization Framework:

Deng et al (2010), J. Geophys. Res., *115, D00J15, doi: 10.1029/2009JD013104.*

Forward Calculation Model:

PSD assumption: Gamma distribution

Particle habits: Hexagonal Column, Bullet Rosette, Aggregate

Radar backscattering: Hong 2007

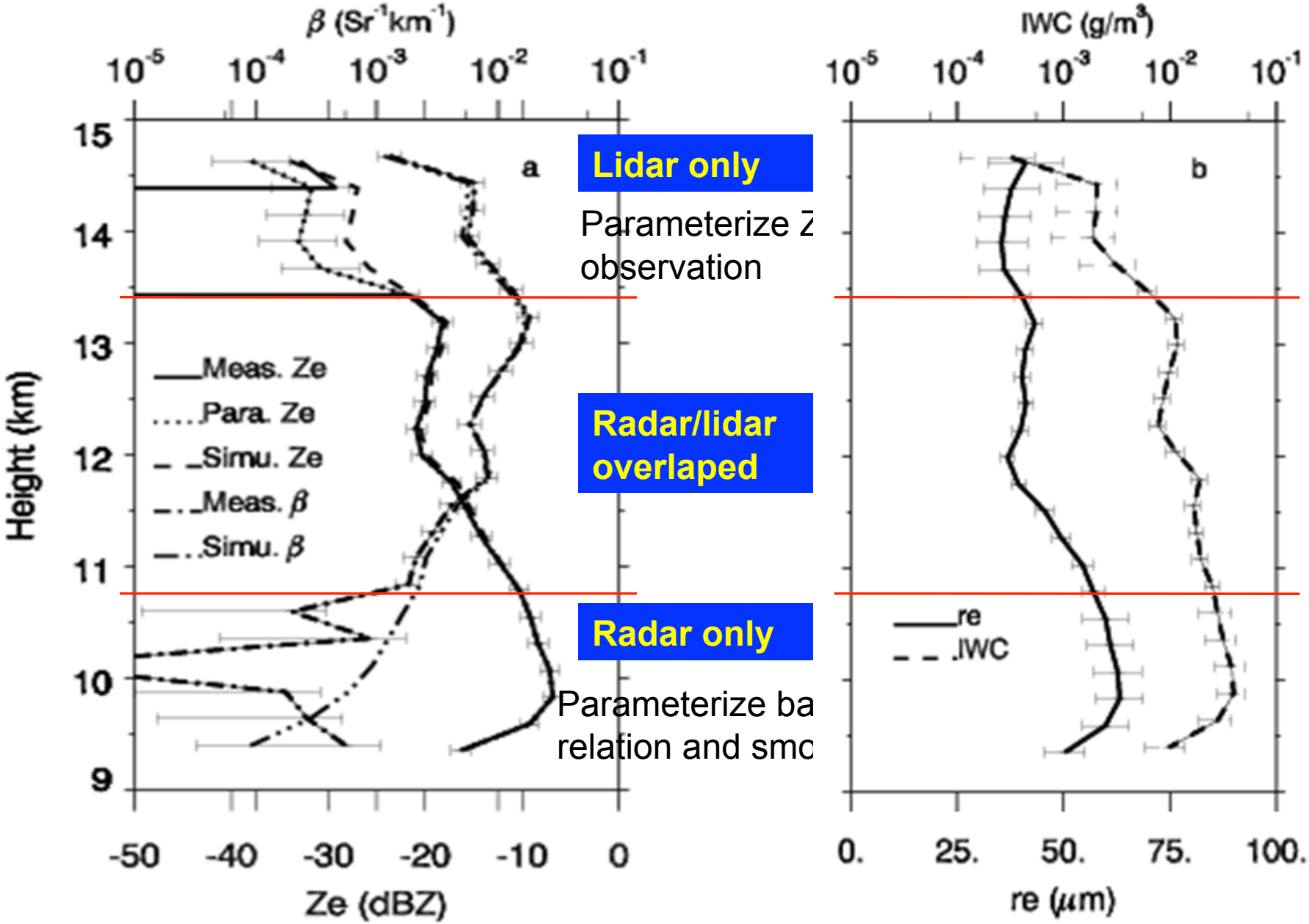
Lidar extinction: Yang et al 2000

Lidar backscattering to extinction ratio: 15 – 30

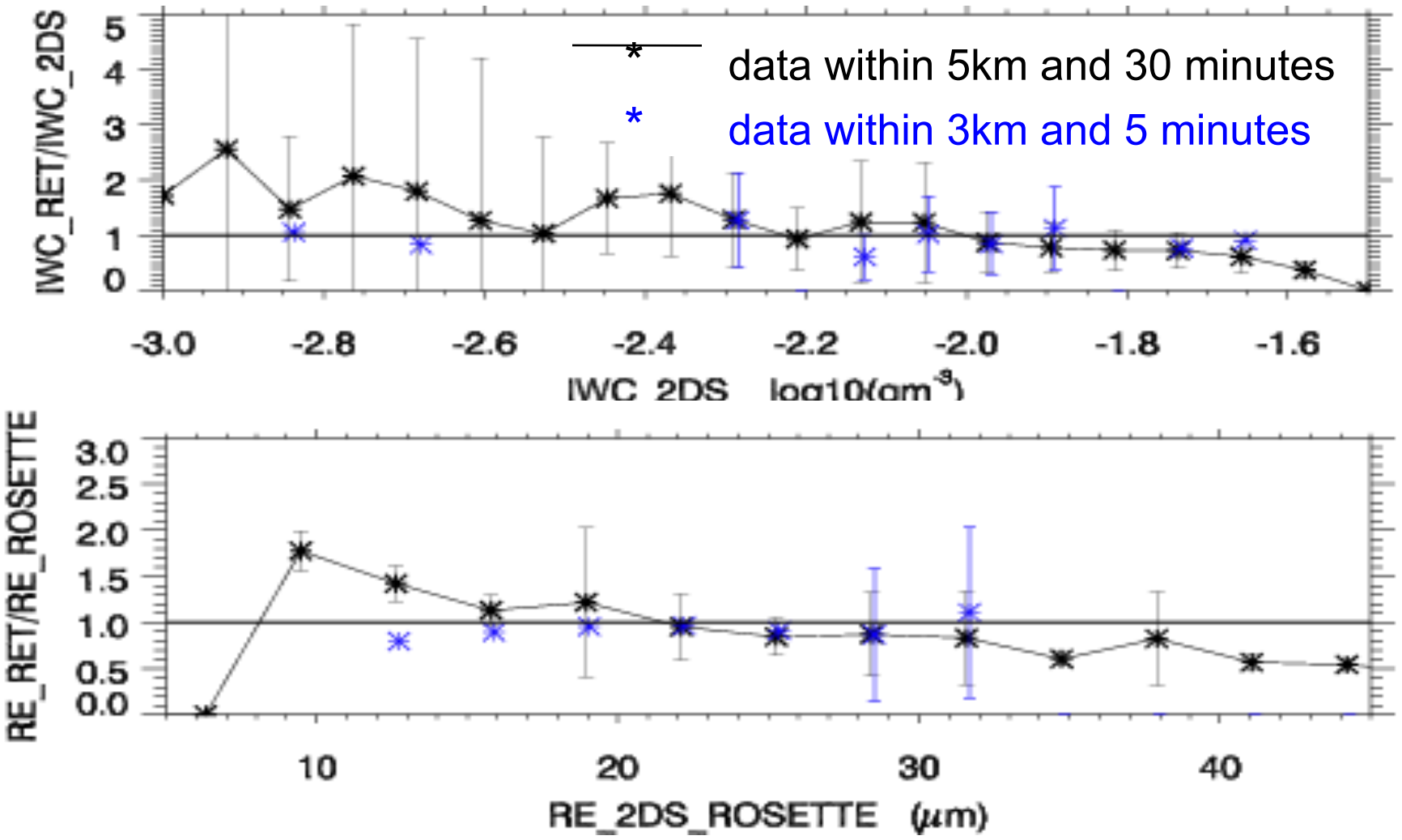
Multiple scattering factor: 0.6

Algorithm outputs: Effective size, Extinction, IWC, and their error estimations

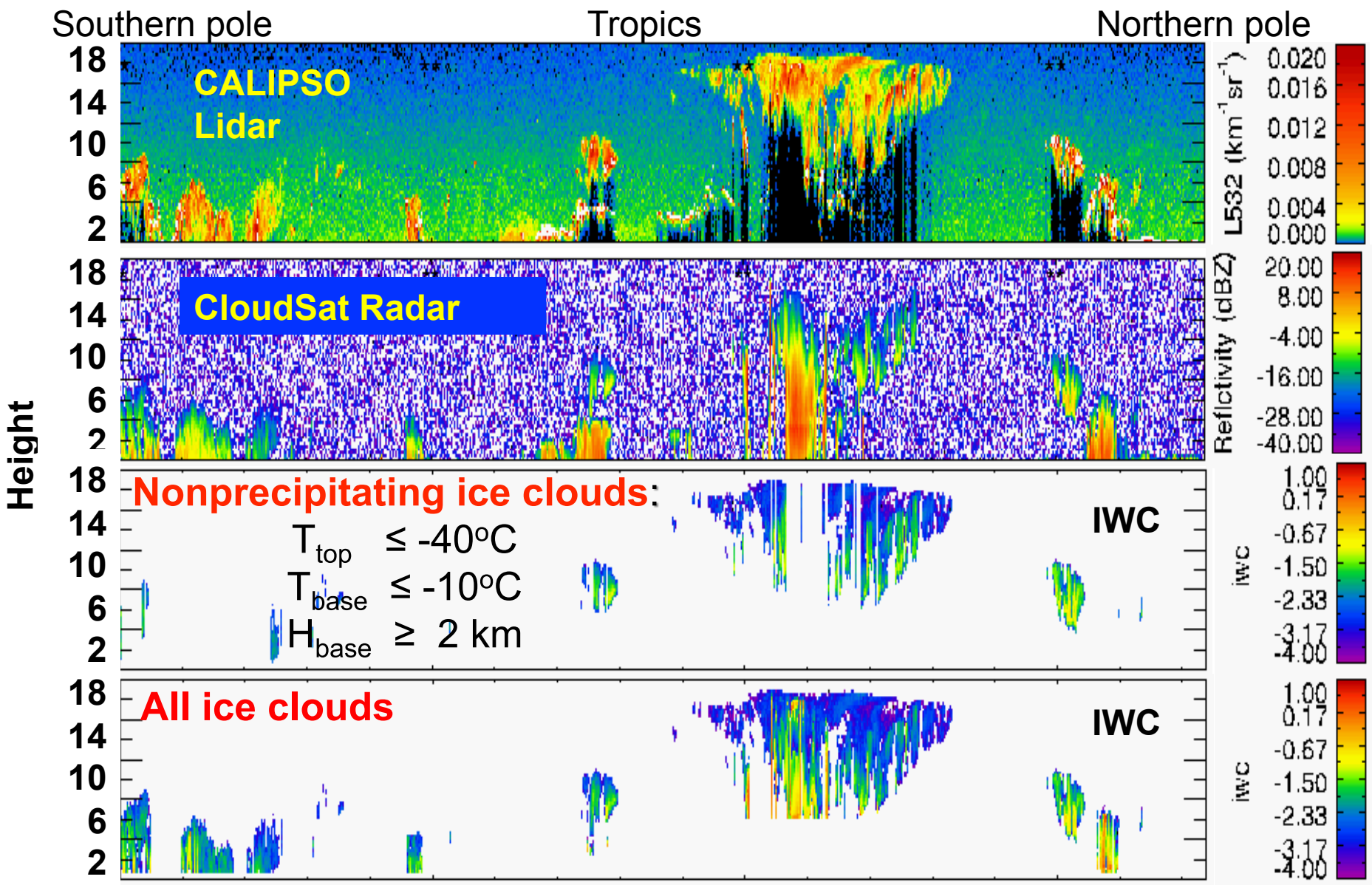
Profiling Retrieval Example



TC4 in situ Validation

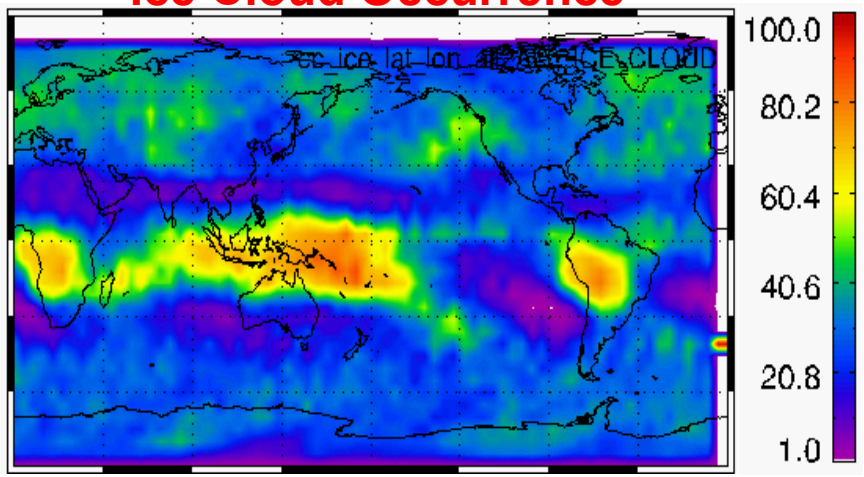


Data Sample (200610-200709)

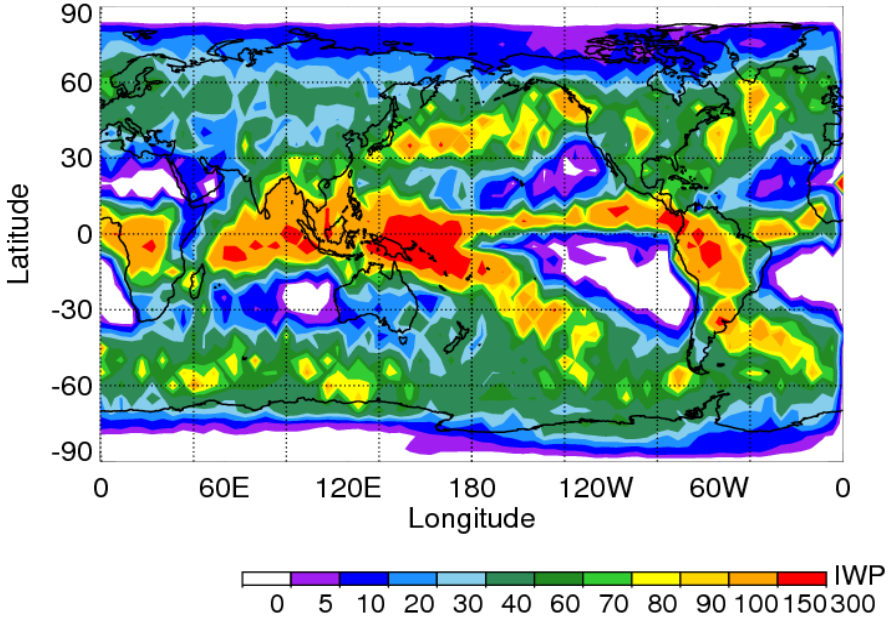


Global ice cloud property
-Initial results from 2C-ICE

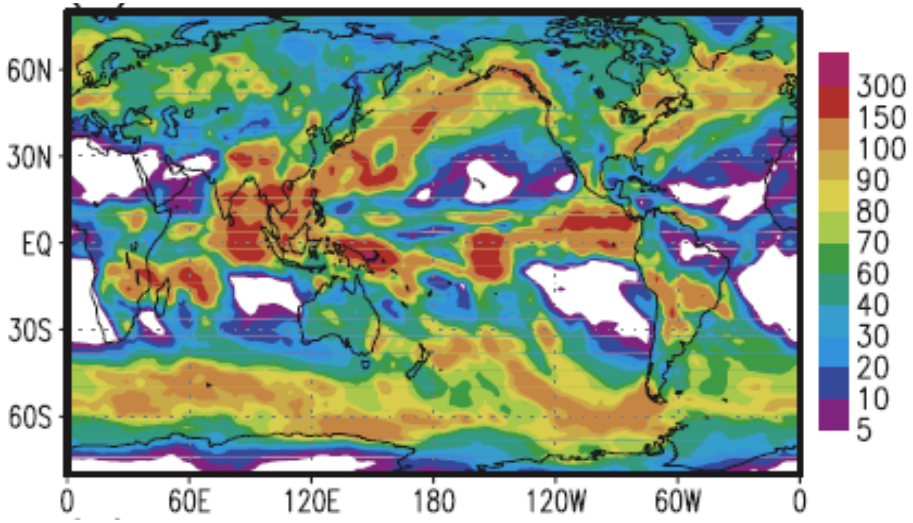
Ice Cloud Occurrence



Total IWP

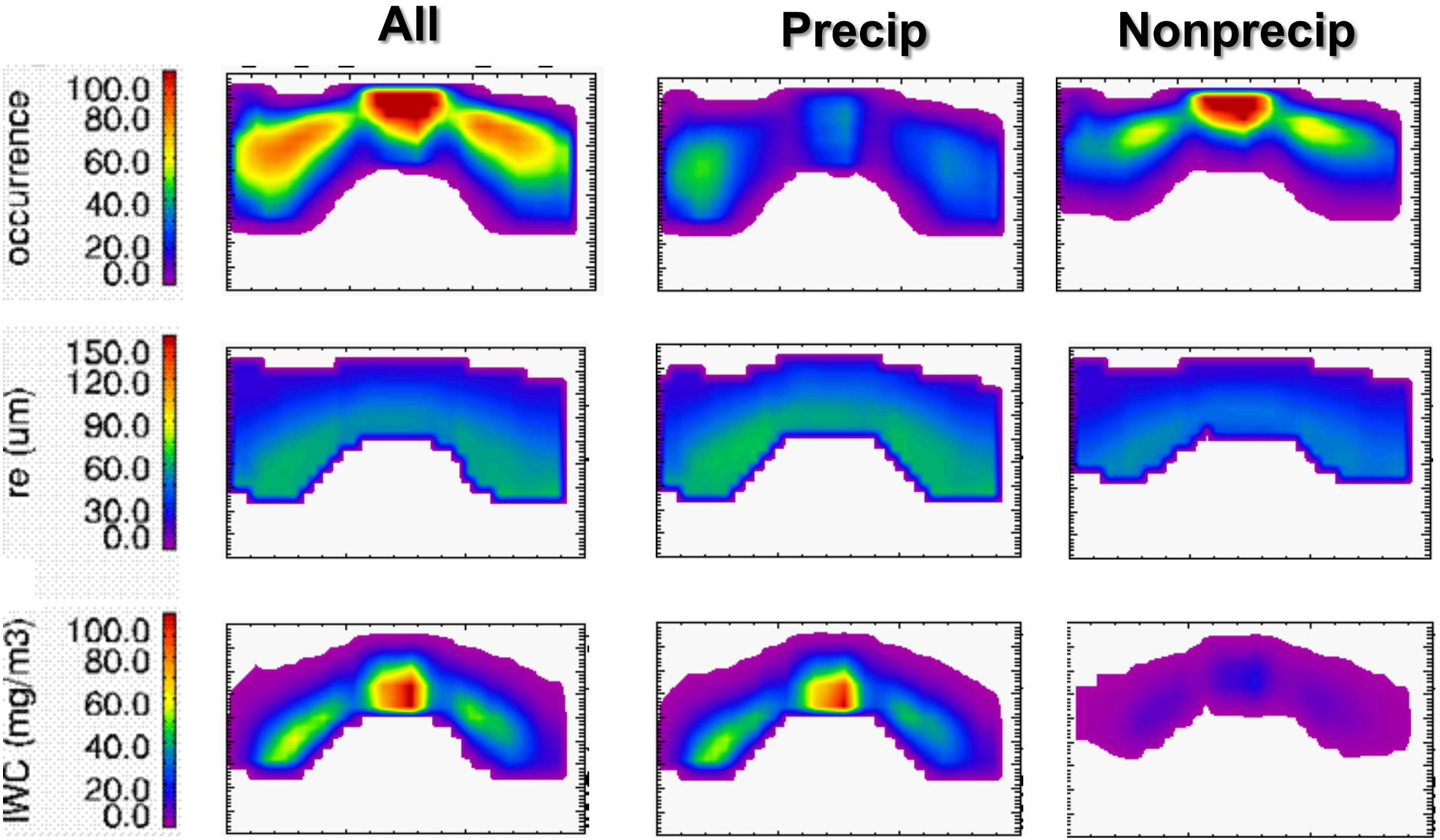


Total IWP from NASA fvMMF



(Waliser et al 2009)

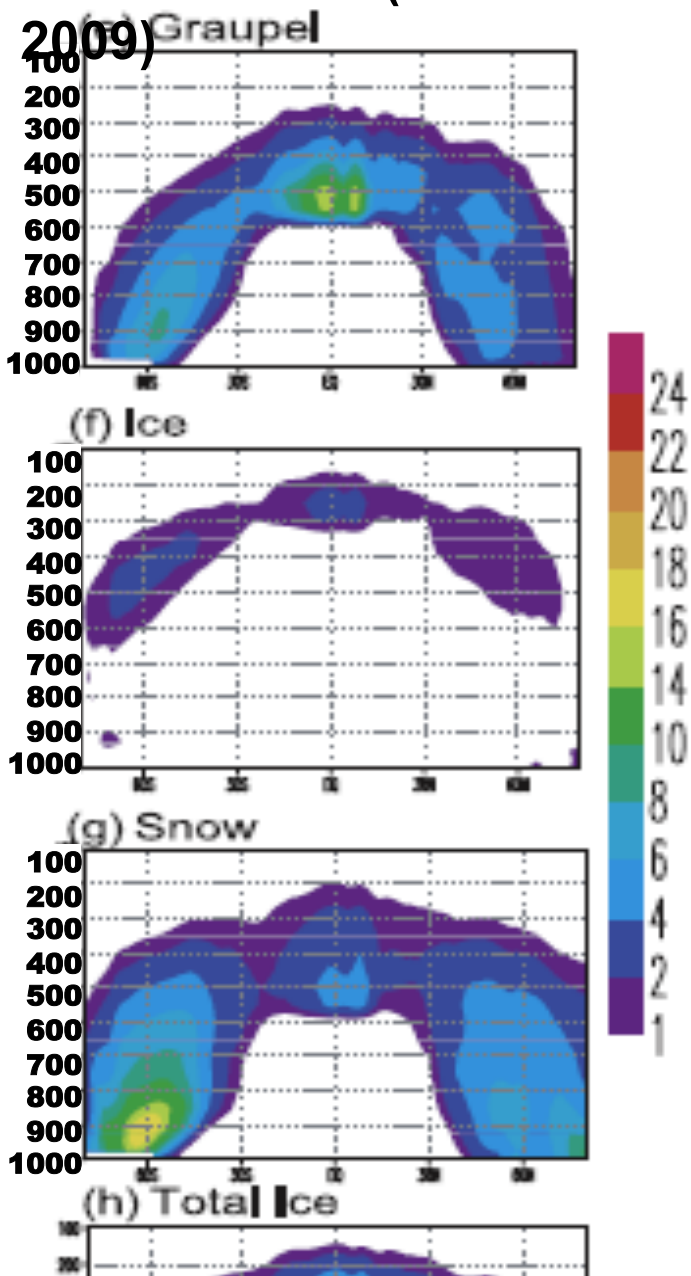
Zonal Mean Ice Cloud Properties

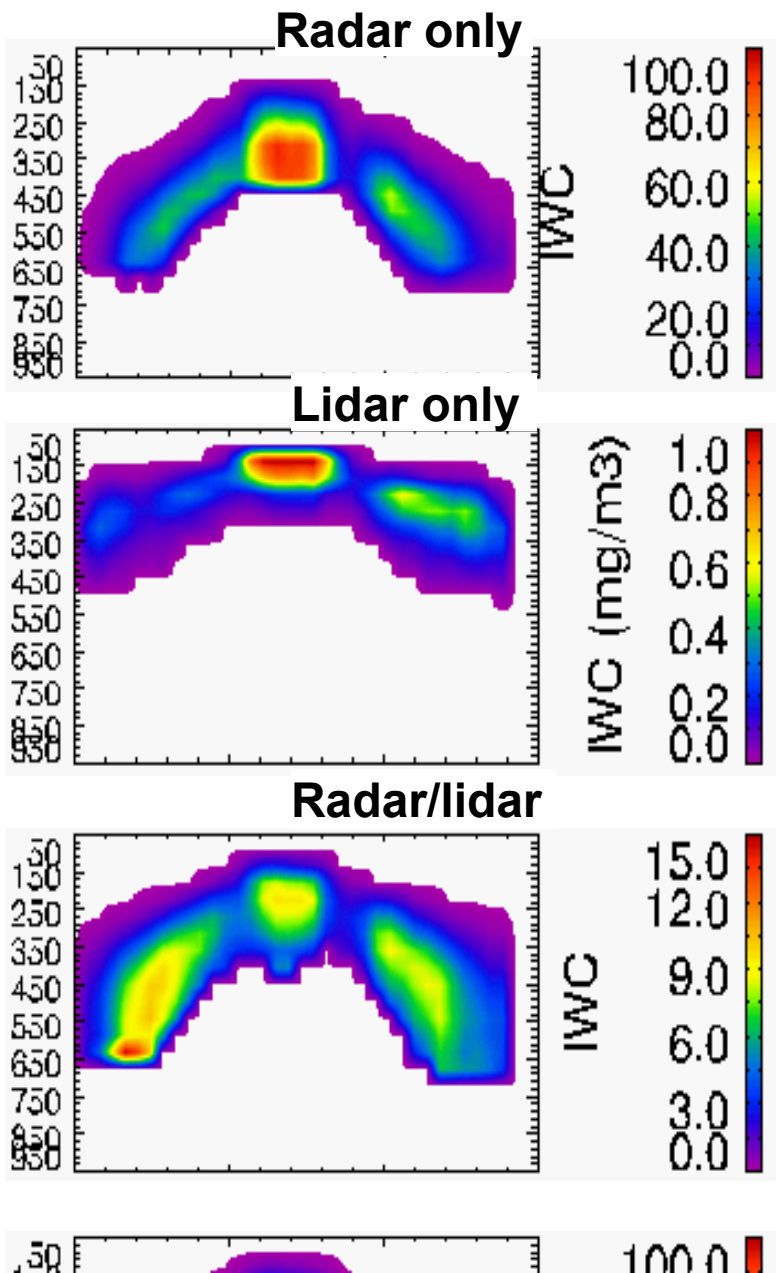


- Ice cloud amount is dominated by nonprecipitating ice clouds;
- Ice mass is dominated by precipitating ice clouds.

New Potentials for Model Evaluation

NASA fvMMF (Waliser et al 2009)





Ice mass is dominated by radar only region.

Lidar only region has more than 70% occurrence in the tropics.

2C-ICE may provide subsets of frozen hydrometers for model validation based on radar, lidar cover zones and precipitating flags.

Summary

- New and improved cloud type including cloud phase and ice microphysical products by combining CloudSat and CALIPSO measurements will soon be available.
- Want some example files or results for interesting cases before the formal R05 release, contact algorithm developers:
  - Zhien Wang zwang@uwyo.edu
  - Jay Mace Jay.Mace@utah.edu
  - Min Deng mdeng2@uwyo.edu

- Suggestion and question?